Fisheries and Oceans Science | Pêches et Océans Sciences

C S A S | **S C C S**

Canadian Science Advisory Secretariat | **Secrétariat canadien de consultation scientifique**

Research Document 2001/046 | **Document de recherche 2001/046**

Not to be cited without permission of the authors [1] | Ne pas citer sans autorisation des auteurs [1]

Assessment of the Margaree River gaspereau fishery, 1997 to 2000

G. Chaput, P. LeBlanc, and R. Crawford[1]

Dept. of Fisheries and Oceans
Science Branch
P.O. Box 5030
Moncton, NB
E1C 9B6

[1]Nova Scotia Dept. of Fisheries
Nova Scotia

[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au Secrétariat.

This document is available on the Internet at: Ce document est disponible sur l'Internet à:
http://www.dfo-mpo.gc.ca/csas/

ISSN 1480-4883
Ottawa, 2001

Canada

102-05534/

Abstract

The Margaree River (NS) gaspereau fishery is prosecuted along a 20 km stretch of river between the estuary and the main spawning area in Lake Ainslie. Alewife (*Alosa pseudoharengus*) are the dominant component of the harvests. There are no quotas but exploitation is controlled by weekly close times staggered between two fishing zones in the river. There have been large annual variations in landings since 1950 with annual landings during 1996 to 2000 averaging just over 200 t and among the lowest of record. Between 1983 and 2000, less than 500 thousand to as many as 6.7 million alewife were harvested in the Margaree River fishery. In 1997, the alewife catch was dominated (96%) by new recruitment. The proportions of previous spawners in 1998 to 2000 are among the highest observed in the time series and reflect reduced exploitation on the 1994 and 1995 year classes. Fishing rate (F) reference points ranging between 0.4 and 0.5 equate to an annual loss of 33% to 39% of the alewife spawning stock migrating to Lake Ainslie. The management plan of 1996 to 2000 was effective in reducing the exploitation rates from those of the previous years and closer to the reference level for this stock. However, abundance of gaspereau and spawning escapement in 2000 remained low. If exploitation rates continue to be low relative to historical levels, more older and larger fish should be available to the fishery and for spawning.

Résumé

La pêche au gaspareau de la rivière Margaree (N-É.) est pratiqué sur 20 km en longueur de rivière depuis l'estuaire jusqu'au lac Ainslie qui est le site de frai. Le gaspareau proprement dit, (*Alosa pseudoharengus*), est la composante dominante des captures. La pêche n'est pas contigentée et l'exploitation est contrainte par des fermetures hebdomadaires étalées sur deux zones de pêche sur la rivière. Depuis 1950, on a observé des importantes fluctuations annuelles dans les captures avec celles depuis 1996 en moyenne 200 t et parmi les plus faibles de la série. Depuis 1983, entre 500 milles et 6,6 millions de gaspareau ont été capturés annuellement dans la pêcherie de la rivière Margaree. La capture en 1997 était constituée majoritairement, à 96%, de nouveau recrutement. Durant 1998 à 2000, des poissons de frai antérieur constituaient des proportions parmi les plus élevées de la série, ceci en conséquence d'un taux d'exploitation réduit des cohortes de 1994 et 1995. Le point de référence en unité de taux de pêche (F) se situe entre 0,4 et 0,5 ce qui équivaut à un prélèvement annuel de 33% à 39% de la migration totale de géniteurs au lac Ainslie. Le plan de gestion de 1996-2000 a permis de réduire les taux d'exploitation à des niveaux près du point de référence. Cependant, l'abondance de gaspareau en 2000 est demeuré faible. Si les taux d'exploitation demeurent inférieurs à ceux des années antérieures, on devrait observé une augmentation de gaspareau de taille et age supérieurs dans les captures et parmi les géniteurs.

INTRODUCTION

The Margaree River gaspereau fishery is prosecuted in-river, above head of tide along a 20 km stretch between the estuary and the main spawning area in Lake Ainslie (Fig. 1). Tip-traps are installed from the bank and generally filter half of the river, from the bank outward. Alewife (*Alosa pseudoharengus*) are the dominant component of the harvests with fewer blueback herring (*Alosa aestivalis*) migrating later (in early June) into the river than alewife. Alewife have returned to the river as early as mid-April but the major run occurs in the second to fourth weeks of May. Crawford (1986) has shown that spawning occurs throughout Lake Ainslie but tended to be concentrated in the shallower Loch Ban portion of the lake (Fig. 1). Juvenile gaspereau leave the lake in late summer and throughout the fall and return to spawn at age three and four years. Adults feed in the southern Gulf of St. Lawrence after spawning and overwinter outside the Gulf of St. Lawrence, along the Atlantic coast of Nova Scotia (Crawford and Tully 1989).

There are no quotas on the river but control of exploitation in recent years has relied on closures to reduce effort and favour escapement into Lake Ainslie. The majority of gaspereau harvested is salted on site and processed by individual fishers. Fishing practices have evolved with mechanical tip-traps adopted by almost all fishers by the early 1980's. The majority of the catch is salted fresh at each fishing site and packed in pails by individual fishermen after curing is complete.

The Margaree River gaspereau fishery has been formally assessed since 1983 (Alexander 1984, Alexander and Vromans 1985, 1986, 1987, 1988; Chaput 1993; Chaput and LeBlanc 1989, 1990; Chaput et al. 1991; Claytor et al. 1995). The last assessment was conducted for the 1995 and 1996 fisheries (Chaput et al. 1997). Other information related to migrations, age structure and physiology were summarized by O'Neil (1980) and Crawford et al. (1986).

The objectives of this assessment are to estimate the exploitation rates in the fishery relative to defined reference levels and to provide a prognosis of stock status.

FISHERIES MANAGEMENT AND LANDINGS

Prior to 1984, there were no within season closed periods for fishing gaspereau on the Margaree River. The fishing season opened April 1 and closed June 30. In 1984, weekend closures were introduced following the assessment that exploitation rates were excessive. The weekend closures consisted of a 18:00 Friday to 8:00 Sunday closure for the section river situated below the Highway 19 bridge (about midway between the estuary and Lake Ainslie) and the 18:00 Saturday to 8:00 AM Monday closure for the fishery above the bridge (Fig. 1). This management measure had the effect of reducing the potential fishing time (traditionally sunrise to sunset) by 20%. In response to concerns by fishers that a chance occurrence of the major run on a weekend closed period could impact on their harvests, an alternative management plan was proposed by the fishers and adopted for the 1992 to 1995 fishery. Under this management plan, traps could be fished in both zones seven days per week but with alternating mornint or evening half day closures every second day. This management plan, described by Chaput (1993) and Claytor et al. (1995) resulted in a slight decrease in potential fishing time from the 1984 to 1991 period (6%) but a 25% reduction relative to the pre-1984 situation. After the 1995 fishery, it was evident that the stock had severely declined (Chaput et al. 1997) and in response, additional closure periods were introduced to the 1996 season: complete closure for three days of the week and half day fishing periods for two of the four remaining fishing days (Table 1). This management regime resulted in a 57% reduction in potential fishing from the pre-1984 period, a 46% reduction from the 1984 to 1991 period and a 43% reduction from the 1992 to 1995 period. It remained in effect during 1996 to 2000.

Regulations require that traps plus leaders and all walkways or other conveyances over the river allow one-half the width of the river to remain open at all times. Additionally, the combined length of trap and leader may not be more than 15 m and no trap may be set within 55 m of another trap.

Potential licensed effort increased from the 21 licenses in 1971, peaked in 1980 at 82 licenses and has stabilized at about 60 licenses since 1989 (Table 2). The fishery is currently restricted by a freeze on new entrants and license or site transfers are permitted only to immediate family members. Active licenses have tended to be substantially less than the potential licenses on the river (Table 2). The decline in active licenses in 1992 was the result of a change in the fisheries inspection regulations which required that all gaspereau destined for human consumption must be cured and processed in a certified building. Several fishers were able to accommodate the inspection regulations in 1993 and active effort increased. The decline in active licenses in 1996 to 2000 has been attributed to the restrictive management plan.

The Margaree River and Statistical District 2 (western Cape Breton Island) landings have undergone large annual variations between 1950 and 2000 The 1995 to 2000 harvests from the Margaree River have averaged just over 200 t, are among the lowest of record, and follow an almost continuous decline from the peak historic catch of 1,666 t in 1988 (Table 2; Fig. 2). High harvest levels were generally short-lived, lasting no more than two years in succession followed by a dramatic decline in the subsequent year (Fig. 2). The harvests of gaspereau from the Margaree River have represented important proportions of the Gulf Nova Scotia harvests (38% to 90%) since 1978 (Table 3). Relative to the southern Gulf gaspereau fisheries, the harvests from the Margaree River have represented 5% to 36% of the total with the lowest percentages of the provincial total (5% to 7%) during 1995 to 2000 (Table 3).

CONSERVATION AND MANAGEMENT OBJECTIVES

Fisheries Management Objective

In past assessments, the status of the gaspereau stock was evaluated relative to the management objective of $F_{0.1}$. Estimation of the fishing mortality for $F_{0.1}$ was based on the yield per recruit analysis method of Thompson and Bell as described in Rivard (1982) under the assumptions of a Type I fishery (natural mortality occurs at a time of year different from the fishing mortality) because the fishery occurs over a period of about four weeks during the year (Chaput and LeBlanc 1989). The estimation of $F_{0.1}$ is sensitive to the assumed natural mortality rate (M) for the species.

An analysis of the population of alewife from South River (Gulf of St. Lawrence shore, Nova Scotia) indicated that the natural mortality of alewife was high (M = 0.44 equivalent to 36% mortality for the year) and increased for previous spawners (M = 1.05 equivalent to 65% mortality for the year) (Chaput and Alexander 1989). These values are much higher than the assumed natural mortality of 0.2 for Atlantic herring (18% annual mortality). Higher natural mortality for gaspereau relative to herring would be expected because of the freshwater spawning migration which gaspereau undertake.

Alternative indicators of natural mortality based on longevity and life history relations suggest that M for alewife should be higher than 0.2. At a maximum spawning age of eleven years for alewife from the southern Gulf, the empirical relationship derived by Hoenig (1983) indicated that M was about 0.4. Jensen (1996) reviewed three life history relations called the Beverton and Holt invariants, one of which provides an indication of the natural mortality on the basis of the age at maturity ($M * m = C1$; where M = natural mortality, m = age at maturity, and C1 = 1.65 or 2). At an average age at maturity of alewife in the Margaree River of 3.4 years (based on the proportion of the recruitment to the river which matures at age 3 years versus 4 years), M equates to 0.5.

Based on the estimated mortality rates from the South River alewife population, $F_{0.1}$ was estimated at F = 1.05 (exploitation rate of 0.65) (Chaput and LeBlanc 1989). At M = 0.4, the target fishing mortality at $F_{0.1}$ declines to 0.6 (exploitation rate of 0.33) while at M = 0.5, the target fishing mortality would be 0.8 (exploitation rate of 0.55).

Walters and Pearse (1996) suggest that F_{opt} (defined as the optimum fishing rate based on the long-term objective of maximizing a logarithmically risk-averse function of catch) is less than two-thirds $F_{0.1}$ of harvestable fish. It has also been suggested that given the uncertainty of estimating and forecasting stock size, the fishing mortality should remain below M (Walters and Maguire 1996). For the alewife stock of the Margaree River, the reference fishing rates (F) should therefore not exceed 0.4 to 0.5.

An alternative reference point calculation is one based on a spawner per recruit contribution analysis. The spawner per recruit analysis provides a measure of the loss of life-time spawning potential resulting from fishing relative to when the population is unfished (Mace 1994). The Spawner per Recruit (SPR) analysis was conducted using biological characteristics of the 1997 to 2000 sampling years, including sex ratio at age and the relative fecundity (based on ovary weight) (Fig. 3). The %SPR was estimated for variable M and the reference points calculated were F_{lim} at 30% SPR and F_{PA} at 50% SPR as suggested by ICES (1997). For M varying between 0.2 and 0.6, the limit fishing mortality rate (F_{lim}) was between 0.35 and 0.55 (Fig. 3). The precautionary fishing mortality rate (F_{pa} at 50% SPR) was between 0.18 and 0.28 (Fig. 3). At an assumed M of 0.4, $F_{lim} = 0.45$ and $F_{pa} = 0.23$.

Based on the above analyses, a fishing rate (F) reference point range of 0.4 to 0.5 seems appropriate for the Margaree River alewife stock. This equates to an annual loss of 33% to 39% of the alewife spawning stock migrating to Lake Ainslie.

ASSESSMENT DATA

The data used in the assessment of the Margaree River gaspereau fishery include logbook reports from individual fishers, two-stage stratified sampling for age composition and derivation of the catch at age, and estimation of the harvests by telephone survey.

Fishery logbooks are used to make inferences on timing of the catch and in the past have been used as an abundance index in cohort analysis (Chaput et al. 1991) and in a depletion estimation procedure (Leslie) to estimate exploitation rates in the current year (Claytor et al. 1995). Logbook contributions in 1996 to 2000 declined from previous years (30% of active licenses returned logbooks) with the highest returns in 1988 (92% participation). Logbook reported harvests in 1996 represented 21% of the estimated harvests. Since 1996, logbooks have been mandatory.

Commercial sampling followed a similar procedure to that used since 1989 (Chaput 1993). Sampling was conducted daily in each of the fishing zones (lower and upper) (Table 4). The objective was to measure 200 to 250 fish from each zone, preferrably from one trap site but several trap sites were visited to obtain the complete length sample when catch rates were low. Detailed samples for species identification, length, weight, sex, maturity and ovary weight were collected by retaining 3 fish for every half cm fork length group up to 28 cm and 5 fish for every half cm group for fish longer than 28 cm. When detailed samples were frozen prior to analysis, fresh fish lengths were estimated from frozen lengths using the following relationship:

adjusted length (mm) = 1.0143 X frozen length (mm) + 4.557

Scales for age determination were collected preferentially from the left side, midway between the dorsal fin and the ventral scutes. Species (alewife, *Alosa pseudoharengus*; blueback herring, *Alosa aestivalis*) were identified on the basis of the external appearance and the peritoneum colour (Scott and Crossman 1973). The peritoneal lining of alewife tends to be pale to dusky whereas the lining of the body cavity of blueback herring is sooty to black.

The catch-at-age of alewife and blueback herring was derived from age-length keys (Table 4) applied to length sampling vectors. Length vectors within each group were weighted by the reported logbook catch for that period. Catch-at-age was first derived for the total logbook catches and then adjusted for the total harvests from the river using the proportion of the total harvests reported in the logbooks.

The total harvests from the Margaree River were obtained from a telephone survey conducted during January to March of each year, after commercial processing of gaspereau was generally completed. Fishers were asked for bait sale amounts as well as the total number of pails of cured gaspereau packed. A 50 lb pail of cured gaspereau was assumed to represent 70 lbs of fresh fish (30 lb pail of cured fish = 42 lbs of fresh fish) (Alexander and Vromans 1988). Estimates of bait sales were obtained by Conservation and Protection Branch field staff. No fishers reported selling bait in 1996.

Continuous (1 to 1.5 hour intervals) water temperature recorders were installed in Loch Ban (Lake Ainslie) and at the Environment Canada water gauging station in the upper part of the Southwest Margaree.

Sampling for gaspereau larvae in Lake Ainslie (the main spawning area for the Margaree River stock) has been conducted during 13 years since 1983. The methods are described in Crawford (1996). Briefly, sampling was conducted weekly from the latter part of May until early July. A five minute surface tow with a half metre plankton net (mesh 300 µm) was conducted at four fixed stations within the Loch Ban portion of the lake. Since 1989, larvae have been identified as prolarvae (with yolk sac) and post-larvae (yolk sac absent). Crawford (1996) calculated the mean index for the year based on the total number of prolarvae and postlarvae combined. The sampling periods when no larvae were observed at any of the four stations were excluded. An alternative index called the integrated index uses the abundance of all larvae within each sampling period (average of the four sites) weighted by the total spawning season as inferred from sampling in the lake. The integrated index takes account of variations in daily abundance and duration of gaspereau larvae presence in the lake. The integrated index is calculated as follows. The average of the two consecutive sampling periods was weighted by the number of days between sampling periods. For the first sampling date, the average number of days between successive sampling events for the year was used to weight half the mean larval abundance at the first sampling event. An example of the calculation for the integrated larval index for 1989 is given below.

Year	Sampling dates Start	End	Days between sampling	Mean Larval Abundance (on End day)	Integrated Larval Index
1989	.	24-May	6.9[1]	3547	12193[2]
1989	24-May	30-May	6	1009	13667[3]
1989	30-May	6-Jun	7	555	5474
1989	6-Jun	13-Jun	7	639	4182
1989	13-Jun	20-Jun	7	456	3835
1989	20-Jun	27-Jun	7	73	1851
1989	27-Jun	4-Jul	7	25	343
1989	4-Jul	11-Jul	7	71	338
1989	11-Jul	18-Jul	7	0	249
Annual index					42131[4]

[1] represents the average number of days between sampling events during 1989
[2] represents the product of the days between sampling (6.9) and the average of 3547 and 0 (mean larval abundance at start and end dates sampled)
[3] represents the product of the days between sampling (6) and the average larval abundance of start and end dates (average of 3547 and 1009)
[4] sum of the integrated larval index column

ESTIMATION OF STOCK PARAMETERS

The timing of the 1997 fishery was similar to 1995 and among the latest observed since monitoring began in 1983 (Table 5). The fisheries of 1998 to 2000 were as early as observed in the 1980s with 50% cumulative catch occurring before May 20 (Fig. 4). Prior to 1990, the 50% cumulative catch occurred between May 17 and May 23, with exception to 1985. Temperature of the river is not a determining factor in the run-timing or catches. Catches of gaspereau occurred when mean water temperatures were less than 10°C in 2000 but in 1998 and 1999, water temperatures were above 10°C before any important catches occurred (Fig. 5).

Between 1983 and 2000, less than 500 thousand to as many as 6.7 million alewife were harvested in the Margaree River fishery with the lowest catches occurring in 1996 and 2000 (Table 6). Blueback catches have been substantially less; a few thousand to no more than 118 thousand fish annually (Table 7). In 1997, the alewife catch was dominated (96%) by new recruitment whereas in 1998 to 2000, new recruitment comprised 43% to 60% of the total alewife catch (Table 6). The proportions of previous spawners in 1998 to 2000 are among the highest observed in the time series and reflect reduced exploitation on the recruitment from 1994 and 1995 (Table 6). For the first time, the dominant age group in the catch was 5 year olds (1995 year class).

The length of alewife in the catches generally declines as the season progresses (Fig. 6). The larger and older alewife are caught first and the mid to end fishery catches are dominated by three-year old new recruitment. The length distribution of alewife in 2000 was wider and the modal length greater than in 1997 to 1999 which reflects the higher abundance of the 5-year old alewife in the catch (Fig. 7).

Estimates of returns, spawners and exploitation rates

Spawning in Lake Ainslie occurs over several weeks but with the highest abundance occurring in one event (Fig. 8). There is generally large variation among sites sampled on a given date (CV: 19% to 200%) and among sampling periods at individual sites (CV: 63% to 227%) (Fig. 8). The index of larval abundance in Lake Ainslie suggests that variable levels of spawning escapement have occurred in Lake Ainslie with two years of exceptionally high escapement (1984 and 1998) and a succession of years of low escapement (1990, 1993, 1994, 1995, and 1996) (Fig. 9). This pattern is consistent regardless of the index considered (integrated, overall average, prolarvae) (Fig. 9).

The total returns and spawning escapements to Lake Ainslie were estimated using cohort analysis with an assumed M of 0.4 for all age groups and years. The integrated larval index was used to tune the current year and oldest year F's by minimizing the log of the escapement and larval index from Lake Ainslie (Table 8). Retrospective patterns were evaluated by estimating the escapement and F's sequentially from 1995 to 2000.

There is an important retrospective pattern in the tuning of the F's using the larval index (Fig. 10). Fishing mortality rates are underestimated and escapement overestimated up to four years post fishery, which corresponds to the number of years (3 to 4 years) required for a converged catch at age (i.e. a year-class is fished out). The larval index to escapement relationship changed dramatically in 1997 and it was not until year 2000 that the general shape recovered to that prior to 1997 (Fig. 11). Accounting for the retrospective pattern, it can be concluded that the fishing mortality rates have declined to about F = 0.5 during 1997 to 2000 from the high levels (generally > F = 1.0) of the years prior to 1996 (Fig. 10). A decline in F was anticipated as a result of the management plan introduced in 1996.

Claytor et al. (1995) used logbook data and the Leslie depletion estimator to derive exploitation rates for the 1991 to 1994 fisheries. The depletion estimates and the exploitation rates estimated by cohort analysis indicate that exploitation rates during 1991 to 1994 were both high and in excess of 0.6 to 0.7 and are consistent with the estimates derived from the cohort analysis in this document.

	1991	1992	1993	1994
Depletion estimate (Claytor et al. 1995)				
Exploitation rate	0.87	0.89	0.85 to 0.96	0.73
Cohort analysis (this paper) assuming M = 0.4				
Exploitation rate	0.64	0.80	0.78	0.72
(F)	(1.02)	(1.62)	(1.52)	(1.27)

Additional evidence of the high exploitation level in this fishery is provided by the counts of gaspereau passing through a counting fence to Lake Ainslie in 1979 relative to the harvest of gaspereau in the same year with the harvests representing between 0.66 and 0.70 of the total run of gaspereau (Chaput et al. 1997).

As the total stock abundance declined (based on estimated runs to the river), the exploitation rates increased. The increased exploitation rate on the smaller run is consistent with the observed behaviour of gaspereau during the migration and the placement of the fishing gear. At low abundance, gaspereau travel in small schools close to the river banks. At very high abundance, gaspereau schools spread across the entire river. Since the commercial traps are installed from the bank towards the middle of the river, at low abundance, each trap exploits a greater proportion of the run than at high abundance.

In the Margaree River fishery, 39% to 91% of the 1980 to 1994 cohorts were harvested before they had a chance to spawn once (Table 9). The total harvests of the cohorts ranged between 53% and 96%. The estimated abundance of the year classes have varied between less than 200 thousand fish (1993 cohort) to a high of more than 10 million alewife (1984 cohort) (Fig. 12). Weak year class failures (less than one million recruits) have occurred in 1986, 1988, 1991 to 1993 (Fig. 12). The year classes of 1981, 1984 and 1985 were exceptionally large.

Spawning escapements into Lake Ainslie are estimated to have varied from about 500 thousand alewife (1992, 1995 and 1996) to almost 5 million spawners in 1987 (Fig. 13). Escapements to Lake Ainslie between 1990 and 1996 have been at or below one million spawners and in 1995 were less than 500 thousand spawners, the lowest of the time series (Fig. 13). A plot of the estimated recruitment (to the river as first time spawners) relative to the estimated spawning stock (from cohort analysis assuming M = 0.4) indicates that an important part of the decreased abundance of recent years was the result of low spawning escapements (Fig. 13). There is large variability in the recruit to spawner relationship, but escapements of less than one million fish (males and females) to Lake Ainslie have produced less than 2 million recruits (to age 3 and 4) in 3 of 5 years. When escapement has exceeded one million spawners, recruitment has exceeded 2 million fish in 6 of 9 years (Fig. 13).

The 1996 year class is small and the 1997 year class size (as estimated from catches of 3 year olds in 2000) appears larger than 1996 but smaller than the 1994 and 1995 year classes. The estimated escapements to Lake Ainslie in 1997 to 2000 have been greater than 1 million spawners (Fig. 10). There is a better chance that recruitment in 2001 to 2005 will be improved relative to that observed in 1996 to 2000.

MANAGEMENT CONSIDERATIONS

1) Were the exploitation rates in 1996 to 2000 greater than the reference levels?

The reference exploitation rate (F_{lim}) suggested for the Margaree fishery is F = 0.5 (from %SPR analysis and based on two-thirds $F_{0.1}$ or F <=M) (Walters and Pearse 1996). The estimated exploitation rates (at an assumed M = 0.4) prior to 1996 were greater than F_{lim}. The exploitation rates between 1996 and 2000 are estimated to have declined to levels closer to but likely still above F_{lim}.

2) Was the 1996 to 2000 management plan effective?

There are strong indications that the management plan of 1996 to 2000 was effective in reducing the exploitation rates from those of the previous years and closer to the reference level for this stock. The consecutive three day closure was initiated to reduce exploitation and to allow alewife to migrate freely from the estuary to the lake. Alexander and Vromans (1989) indicated that in 1988, alewife required, on average, 148 hours (6 days) to pass through the 20 km fishing zone. Fishers of the Margaree River feel that alewife can ascend to the lake within one to two days based on the synchrony of catches between lower and upper traps. Alewife can ascend the river more quickly if there are no traps in the river and no fishing activity to deter their upstream migrations.

The higher abundance of five year old alewife in the catch in 2000 is indicative of reduced exploitation and increased survival to older ages. The catch of six year old alewife is the highest observed since the 1984 and 1985 year classes were available in the fishery (Table 6). An expanded age composition in the fishery and larger average size resulting from a higher proportion of older fish are desirable and anticipated stock status indicators. However, abundance of alewife and spawning escapement in 2000 remained low.

3) What is the conservation definition for alewife?

Minimum spawning stock biomass as a conservation definition for the Margaree River alewife has not been defined. There are indications from estimates of escapements and returns in previous years that escapements to the lake of less than one million fish have resulted in recruitment of less than two million fish. Recruitment to the river from combined year-classes has frequently exceeded 10 million fish and year-class production can attain 8 to 10 million fish.

Fixed harvest rates have been suggested as more appropriate for ensuring the sustainability of fisheries (Walters and Pearse 1996). For the Margaree River alewife fishery, an exploitation rate of 0.32 to 0.4 (F = 0.4 to 0.5) would be appropriate. A fixed harvest rate strategy would take advantage of large recruitment, in terms of harvests and spawning escapement. The challenge is to ensure that exploitation rates on low runs to the river do not exceed the levels defined at F_{lim} because catchability is higher at low abundance.

4) What is the prognosis for 2001 to 2005?

Improved escapements in 1997 to 2000 will provide a higher chance of recruitment in excess of two million fish over the next five years. If exploitation rates continue to be low relative to historical levels, more older and larger fish should be available to the fishery and for spawning. An expanded age structure in the catch and in the spawning escapement is desirable and should be possible if exploitation rates are maintained or further reduced from present levels.

REFERENCES

Alexander, D.R. 1984. Status of the Margaree River gaspereau fishery (1983). CAFSAC Res. Doc. 84/17. 14p.

Alexander, D.R. and A.H. Vromans. 1985. Status of the Margaree River gaspereau fishery (1984). CAFSAC Res. Doc. 85/91. 17p.

Alexander, D.R. and A.H. Vromans. 1986. Status of the Margaree River gaspereau fishery (1985). CAFSAC Res. Doc. 86/31. 17p.

Alexander, D.R. and A.H. Vromans. 1987. Status of the Margaree River gaspereau fishery (1986). CAFSAC Res. Doc. 87/18. 17p.

Alexander, D.R. and A.H. Vromans. 1988. Status of the Margaree River alewife (*Alosa pseudoharengus*) fishery 1987. CAFSAC Res. Doc. 88/25. 25p.

Chaput, G., P. LeBlanc, and R. Crawford. 1997. Assessment of the Margaree River gaspereau fishery, 1995 and 1996. DFO CSAS Res Doc. 97/76.

Chaput, G.J. 1993. Assessment of the Margaree River gaspereau fisheries, 1991 and 1992. DFO Atlantic Fisheries Res. Doc. 93/19.

Chaput, G.J. and D.R. Alexander. 1989. Mortality rates of alewife in the southern Gulf of St. Lawrence. CAFSAC Res. Doc. 89/38.

Chaput, G.J. and C.H. LeBlanc. 1989. Assessment of the Margaree River gaspereau fishery, 1988. CAFSAC Res. Doc. 89/29.

Chaput, G.J. and C.H. LeBlanc. 1990. Assessment of the Margaree River gaspereau fishery, 1989. CAFSAC Res. Doc. 90/33.

Chaput, G.J., C.H. LeBlanc, and G. Nielsen. 1991. Assessment of the Margaree River gaspereau fishery, 1990. CAFSAC Res. Doc. 91/12.

Claytor, R.R., P. LeBlanc, R. Jones, and G. Chaput. 1995. Status of gaspereau in the Margaree River 1993 and 1994. DFO Atlantic Fisheries Res. Doc. 95/64.

Crawford. R.H. 1983. The gaspereau fishery of the S.W. Margaree River, 1983. Nova Scotia Department of Fisheries. 16p.

Crawford, R.H. 1986. Larval gaspereau abundance in Lake Ainslie and the recruitment process. Nova Scotia Department of Fisheries. 20p.

Crawford, R. 1996. Status of larval gaspereau abundance in Lake Ainslie 1983-1996. Nova Scotia Department of Fisheries.

Crawford, R.H., R.R. Cusack, and T.R. Parlee. 1986. Lipid content and energy expenditure in the spawning migration of alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*). Can. J. Zool. 64: 1902-1907.

Crawford, R. and D. Tully. 1989. The biology of gaspereau from Pictou Harbour, Nova Scotia. Marine Resource Division, Nova Scotia Department of Fisheries. 41p.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. U.S. Vol. 81:898-902.

ICES 1997/Assess:7. Report of the Study Group on the precautionary approach to fisheries management. ICES 1997/Assess:7.

Jensen, A.L. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Can. J. Fish. Aquat. Sci. 53: 820-822.

Mace. P.M. 1994. Relationships between common biological reference points used as thresholds and targets of fisheries management strategies. Can. J. Fish. Aquat. Sci. 51:110-122.

O'Neil, J.T. 1980. Aspects of the life histories of anadromous alewife *Alosa pseudoharengus* (Wilson), and the blueback herring, *A. aestivalis* (Mitchell) in the Southwest Margaree River and Lake Ainslie, Nova Scotia, 1978-1979. M.Sc. Thesis, Acadia University, Wolfville, Nova Scotia.

Rivard, D. 1982. APL programs for stock assessment. Can. Tech. Rep. Fish. Aquat. Sci. No. 1091. 146 p.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Bull. Fish. Res. Board Can. No. 184. 966p.

Walters, C. and J.-J. Maguire. 1996. Lessons for stock assessment from the northern cod collapse. Reviews in Fish Biology and Fisheries 6: 125-137.

Walters, C. and P.H. Pearse. 1996. Stock information requirements for quota management systems in commercial fisheries. Reviews in Fish Biology and Fisheries 6:21-42.

Table 1. Margaree River, N.S. gaspereau fishery fishing schedule for the 1997 to 2000. AM fisheries open at sunrise and close at 13:00 the same day. PM fisheries open at 13:00 and close at dusk. Full day fisheries are open from sunrise to dusk. During the 1996 to 2000 seasons, the lower and upper zones were closed from sunrise to dusk for three consecutive days.

		1997		1998	
	Week	Lower	Upper	Lower	Upper
May 1	1	Full	PM	PM	Full
2	1	PM	Full	Full	AM
3	1	Full	AM	Closed	Closed
4		Closed	Closed	Closed	Closed
5		Closed	Closed	Closed	Closed
6	2	Closed	Closed	PM	Full
7	2	PM	Full	Full	AM
8	2	Full	AM	AM	Full
9	2	AM	Full	Full	PM
10	2	Full	PM	Closed	Closed
11		Closed	Closed	Closed	Closed
12		Closed	Closed	Closed	Closed
13	3	Closed	Closed	Full	AM
14	3	Full	AM	AM	Full
15	3	AM	Full	Full	PM
16	3	Full	PM	PM	Full
17	3	PM	Full	Closed	Closed
18		Closed	Closed	Closed	Closed
19		Closed	Closed	Closed	Closed
20	4	Closed	Closed	Full	PM
21	4	Full	PM	PM	Full
22	4	PM	Full	Full	AM
23	4	Full	AM	AM	Full
24	4	AM	Full	Closed	Closed
25		Closed	Closed	Closed	Closed
26		Closed	Closed	Closed	Closed
27	5	Closed	Closed	AM	Full
28	5	AM	Full	Full	PM
29	5	Full	PM	PM	Full
30	5	PM	Full	Full	AM
31	5	Full	AM	Closed	Closed

		1997		1998	
	Week	Lower	Upper	Lower	Upper
June 1		Closed	Closed	Closed	Closed
2		Closed	Closed	Closed	Closed
3	6	Closed	Closed	PM	Full
4	6	PM	Full	Full	AM
5	6	Full	AM	AM	Full
6	6	AM	Full	Full	PM
7	6	Full	PM	Closed	Closed
8		Closed	Closed	Closed	Closed
9		Closed	Closed	Closed	Closed
10	7	Closed	Closed	Full	AM
11	7	Full	AM	AM	Full
12	7	AM	Full	Full	PM
13	7	Full	PM	PM	Full
14	7	PM	Full	Closed	Closed
15		Closed	Closed	Closed	Closed
16		Closed	Closed	Closed	Closed
17	8	Closed	Closed	Full	PM
18	8	Full	PM	PM	Full
19	8	PM	Full	Full	AM
20	8	Full	AM	AM	Full
21	8	AM	Full	Closed	Closed
22		Closed	Closed	Closed	Closed
23		Closed	Closed	Closed	Closed
24	9	Closed	Closed	AM	Full
25	9	AM	Full	Full	PM
26	9	Full	PM	PM	Full
27	9	PM	Full	Full	AM
28	9	Full	AM	Closed	Closed
29		Closed	Closed	Closed	Closed
30		Closed	Closed	Closed	Closed

Table 1 (continued).

			1999		2000						1999		2000	
		Week	Lower	Upper	Lower	Upper			Week	Lower	Upper	Lower	Upper
May	1	1	Full	AM	Closed	Closed	June	1	5	Closed	Closed	Full	AM
	2		Closed	Closed	Closed	Closed		2	5	PM	Full	AM	Full
	3	1	Closed	Closed	PM	Full		3	5	Full	AM	Full	PM
	4	1	Closed	Closed	Full	AM		4	5	AM	Full	Closed	Closed
	5	1	PM	Full	AM	Full		5	5	Full	PM	Closed	Closed
	6	1	Full	AM	Full	PM		6		Closed	Closed	Closed	Closed
	7	1	AM	Full	Closed	Closed		7	6	Closed	Closed	Full	AM
	8	1	Full	PM	Closed	Closed		8	6	Closed	Closed	AM	Full
	9		Closed	Closed	Closed	Closed		9	6	Full	AM	Full	PM
	10	2	Closed	Closed	Full	AM		10	6	AM	Full	PM	Full
	11	2	Closed	Closed	AM	Full		11	6	Full	PM	Closed	Closed
	12	2	Full	AM	Full	PM		12	6	PM	Full	Closed	Closed
	13	2	AM	Full	PM	Full		13		Closed	Closed	Closed	Closed
	14	2	Full	PM	Closed	Closed		14	7	Closed	Closed	Full	PM
	15	2	PM	Full	Closed	Closed		15	7	Closed	Closed	PM	Full
	16		Closed	Closed	Closed	Closed		16	7	Full	PM	Full	AM
	17	3	Closed	Closed	Full	PM		17	7	PM	Full	AM	Full
	18	3	Closed	Closed	PM	Full		18	7	Full	AM	Closed	Closed
	19	3	Full	PM	Full	AM		19	7	AM	Full	Closed	Closed
	20	3	PM	Full	AM	Full		20		Closed	Closed	Closed	Closed
	21	3	Full	AM	Closed	Closed		21	8	Closed	Closed	AM	Full
	22	3	AM	Full	Closed	Closed		22	8	Closed	Closed	Full	PM
	23		Closed	Closed	Closed	Closed		23	8	AM	Full	PM	Full
	24	4	Closed	Closed	AM	Full		24	8	Full	PM	Full	AM
	25	4	Closed	Closed	Full	PM		25	8	PM	Full	Closed	Closed
	26	4	AM	Full	PM	Full		26	8	Full	AM	Closed	Closed
	27	4	Full	PM	Full	AM		27		Closed	Closed	Closed	Closed
	28	4	PM	Full	Closed	Closed		28	9	Closed	Closed	PM	Full
	29	4	Full	AM	Closed	Closed		29	9	Closed	Closed	Full	AM
	30		Closed	Closed	Closed	Closed		30	9	PM	Full	AM	Full
	31	5	Closed	Closed	PM	Full							

Table 2. Historic harvests of gaspereau from Statistical District 2, from the Margaree River and total licenses and active licenses.

	Landings (metric tons)				Total	Active	Logbooks
Year	District 2		Margaree River		Licenses	Licenses	Returned
1950	713						
1951	755						
1952	964						
1953	638						
1954	1,275						
1955	1,163						
1956	859						
1957	58						
1958	395						
1959	496						
1960	531						
1961	423						
1962	556						
1963	551						
1964	640						
1965	875						
1966	320						
1967	185						
1968	188						
1969	251						
1970	408						
1971	620				21		
1972	965				25		
1973	1,113				27		
1974	1,681				37		
1975	1,238				61		
1976	497				44		
1977	1,202				39		
1978	1,713				62		
1979	1,776				81		
1980	1,069				82		
1981	1,369				75		
1982	1,445				67		
1983	580		579	*	69	44	9
1984	883	*	883	*	68	45	42
1985	1,223	*	1,223	*	68	25	18
1986	545	*	623		68	33	13
1987	1,259	*	1,259	*	68	33	23
1988	1,912		1,686	*	69	38	35
1989	1,506		1,123	*	59	41	32
1990	1,016	*	1,016	*	62	41	30
1991	641		450	*	62	32	20
1992	617		553	*	62	27	14
1993	802		736	*	60	37	17
1994	498	*	498	*	59	36	18
1995	217	*	217	*	59	33	13
1996	105	*	94	*	59	24	7
1997	218		201	*	59	17	20
1998	308		284	*	59	24	24
1999	256		223	*	59	23	23
2000	132		121	*	59	18	23
		* Estimates from Science Branch					

Table 3. Gaspereau landings (t) from Margaree River, Nova Scotia (NS), New Brunswick (NB), and Prince Edward Island (PEI) statistical districts from 1978 to 2000. Data are summarized from purchase slip and supplementary "B" slips compiled by Statistics Branch. Asterisk indicate values compiled by Science Branch. The landings by province and districts (other than Margaree River) for 2000 are preliminary.

		Nova Scotia Statistical Districts										
Year	Margaree	2	3	11	12	13	45	46	NS	NB	PEI	Gulf
1978		1713	5	36	7	32	118	0	1911	3084	104	5099
1979		1776	0	114	9	49	74	0	2024	4409	405	6837
1980		1069	0	910	21	80	76	12	2167	4676	253	7097
1981		1369	1	61	13	78	103	30	1653	2708	259	4620
1982		1445	0	29	18	34	115	21	1663	1994	133	3790
1983		580	0	144	27	16	10	3	780	1901	36	2717
1984	883*	883	0	78	7	85	0	0	1052	1717	88	2857
1985	1,223*	1223	0	0	1854	100	26	0	3203	3569	238	7011
1986	545*	623	0	161	32	236	0	0	1052	2261	464	3699
1987	1,259*	1259	0	848	59	128	122	144	2559	4419	364	7342
1988	1,666*	1912	-	570	120	225	-	8	2835	3714	233	6782
1989	1,123*	1506	-	245	148	130	75	12	2116	3681	133	5929
1990	1,016*	1016	-	226	1	202	33	26	1504	3196	84	4784
1991	450*	641	0	218	60	110	1	40	1070	3554	87	4711
1992	553*	617	-	101	20	23	-	11	772	3454	318	4544
1993	736*	802	-	73	40	24	0	12	951	3573	198	4722
1994	498*	498	-	77	21	10	-	11	617	3246	95	3958
1995	217*	217	-	25	7	7	58	55	368	3230	34	3632
1996	94*	105	-	1	4	7	99	49	265	1828	53	2051
1997	201*	218	-	1	-	-	1	0	220	2703	107	3030
1998	284*	308	-	24	20	8	155	28	544	3626	52	4222
1999	223*	256	-	7	16	5	123	45	452	3250	93	3795
2000	121*	132	-	0	29	-	114	-	275	1616	53	1944

Table 4. Dates, sites, periods and numbers of fish sampled in 1997 to 2000 for the Margaree River, N.S. gaspereau fishery. Boxes define sample groupings for age-length keys for deriving the catch at age.

	1997						1998					
	Lower			Upper			Lower			Upper		
	Site	Period	Sample size	Site	Period	Sample size	Site	Period	Sample size	Site	Period	Sample size
May 1												
2							5 AM,PM		285			
3							5 AM		70			
4												
5												
6							26 PM		279			
7												
8							5 AM		297	38 PM		281
9							17 PM		227			
10												
11												
12												
13												
14							17 AM		262			
15							5,26 AM,PM		585			
16							5 PM		296	38 PM		275
17												
18												
19												
20												
21	17 PM		44									
22	5,17 PM		250				5 AM		292			
23							26 AM		296			
24	17 AM		41									
25												
26												
27										38 PM		104
28				41 PM		225				38 PM		250
29	17 AM		246				26 PM		314			
30	26 PM		251	35 AM		227	17 AM		295			
31												
June 1												
2												
3							5 PM		284			
4				38 PM		267						
5	5 PM		268									
6				41 PM		268	5 AM,PM		67			
7												
8												
9												
10							17 AM,PM		42			
11	17 PM		273									
12	26 AM		260									
13	17 PM		243				17 PM		31			
14	26 PM		257									
15												
16												
17												
18	17 PM		217									
19	26 PM		265									
20	5 PM		155									
Total samples			2770			987			3922			910

Table 4 (continued).

	1999						2000					
	Lower			Upper			Lower			Upper		
	Site	Period	Sample size	Site	Period	Sample size	Site	Period	Sample size	Site	Period	Sample size
May 1												
2												
3												
4												
5	5 PM	200					17 PM	121		41 AM	112	
6							2,25 AM,PM	449				
7	17 AM	202		37 PM	134		26 AM	279		38 PM	314	
8	5,26 AM,PM	416					5 AM	120				
9												
10												
11												
12	5 PM	304		35 AM	200		26 PM	306		64 AM	313	
13	17 AM	276					26 AM	296		64 PM	304	
14				38 PM	142					41 PM	299	
15				35 AM	299		26 PM	319		64 AM	206	
16												
17												
18												
19	26 AM	315					5,26 AM,PM	597				
20				35 PM	270		5,26 PM	610		38 AM	299	
21	15 PM	264		35 AM	266		26 PM	216		38 AM	315	
22	17 AM	304		38 PM	280		26 AM	298		35 PM	143	
23												
24												
25												
26	17 AM	243								41 PM	280	
27	26 AM	282					26 AM	342		38 PM	229	
28				38 AM	350		26 PM	315		38 AM	295	
29				38 AM	50		26 PM	198		41 AM	289	
30												
31												
June 1							26 PM	303		41 AM	311	
2	5 PM	74					5 PM	320				
3				38 AM	112		5 AM	149		38 PM	315	
4	5 AM	95					26 AM,PM	171				
5												
6												
7							26 AM,PM	621				
8												
9							26 AM,PM	592				
10				38 AM	21		26 PM	303		38 AM	66	
11	17 AM	182										
12				38 AM	73							
13												
14												
15										38 AM,PM	425	
16												
17												
18												
19												
20												
Total samples			3157			2197			6925			4515

Table 5. Timing of the catches of gaspereau in the Margaree River fishery as inferred from logbook reports for 1983 to 2000.

Year	Maximum Catch	Cumulative 10%	Cumulative 50%	Cumulative 90%	Total Days For 10% to 90%	Logbook Catch (mt)	Estimated Landings (mt)
1983	May 17	May 10	May 17	May 24	15	113	579
1984	May 17	May 16	May 21	May 28	12	637	883
1985	May 30	May 21	May 28	June 02	12	506	1223
1986	May 17	May 09	May 17	May 26	15	213	545
1987	May 13	May 12	May 16	May 26	15	882	1259
1988	May 22	May 17	May 23	May 29	13	1375	1666
1989	May 18	May14	May 19	May 23	10	973	1123
1990	June 04	May 13	May 29	June 04	22	780	1016
1991	May 31	May 18	May 28	May 31	13	208	450
1992	June 02	May 24	June 01	June 04	12	359	553
1993	May 23	May 18	May 27	June 05	19	439	736
1994	May 19	May 19	May 29	June 05	18	273	498
1995	June 10	May 25	June 06	June 12	19	83	217
1996	May 23	May 23	May 23	June 06	15	20	94
1997	June 4	May 29	June 6	June 14	11	237	201
1998	May 16	May 9	May 20	May 30	13	272	284
1999	May 20	May 8	May 19	May 28	12	208	223
2000	May 17	May 5	May 16	May 31	15	103	121

Table 6. Alewife catch-at-age for the Margaree River, N.S. gaspereau fishery. First number in age indicates total age, second number indicates age at first spawning. Catch is expressed in thousands (number) of fish. YC=year-class.

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
2.2	0	0	25	2	0	0	1	0	6	5	0	0	0	1	0	0	0	1
3.3	713	2601	447	1262	4400	2479	120	2806	422	1774	2460	19	345	73	1089	564	72	137
3.2	2	0	107	16	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Total 3	715	2601	554	1278	4400	2479	120	2806	422	1778	2460	19	345	73	1089	564	72	137
4.4	371	428	3070	235	434	1431	2444	281	1283	188	565	1448	115	242	21	225	386	54
4.3	397	258	920	159	429	2355	1236	54	41	133	151	240	31	86	18	505	261	29
4.2	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0
Total 4	768	687	3990	394	873	3786	3680	335	1324	321	716	1688	146	328	38	731	646	83
5.5	0	0	0	0	0	0	1	36	35	0	8	17	8	6	1	0	1	3
5.4	157	35	205	372	131	267	186	628	56	47	40	63	209	13	13	3	45	99
5.3	334	185	41	129	19	160	181	244	55	97	21	82	89	3	10	6	132	93
Total 5	491	221	245	501	149	426	368	908	146	144	69	162	307	22	24	10	178	195
6.6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
6.5	5	1	1	7	0	0	0	1	0	0	0	1	2	0	0	0	0	0
6.4	45	20	6	11	181	0	11	23	19	1	7	7	5	13	1	1	1	16
6.3	52	4	27	6	5	7	6	55	20	2	7	4	0	7	0	0	1	27
Total 6	103	26	34	23	186	7	17	79	39	3	14	12	7	21	1	1	2	44
7.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
7.4	0	4	0	4	0	0	0	4	1	0	0	0	0	1	1	0	0	0
7.3	18	1	3	0	0	0	0	3	1	0	0	0	0	0	1	0	0	0
Total 7	18	5	3	4	0	0	0	7	3	0	0	0	0	1	1	0	0	0
8.4	3	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total 8	5	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.4	0	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total 9	5	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2105	3586	4853	2202	5608	6700	4186	4135	1940	2249	3259	1881	805	446	1153	1305	898	460
% new recruit	51	84	73	68	86	58	61	76	90	87	93	79	58	72	96	60	51	43
Major YC	1979	1981	1981	1983	1984	1984	1985	1987	1987	1989	1990	1990	1992	1992	1994	1994	1995	1995
Age	4	3	4	3	3	4	4	3	4	3	3	4	3	4	3	4	4	5
% of Total	36	72	82	58	78	57	88	68	68	79	75	90	43	74	94	56	72	42

Table 7. Blueback herring catch-at-age for the Margaree River, N.S. gaspereau fishery. First number in age indicates total age, second number indicates age at first spawning. Catches are numbers of fish. YC=year-class.

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1.1	0	42	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.
3.3	0	51	138	169	675	2152	0	13264	49289	93562	39717	190	.	.	.	.	.	.
3.2	0	1093	1419	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.
Total 3	0	1144	1557	169	675	2152	0	13264	49289	93562	39717	190	.	.	.	.	.	.
4.4	0	0	7115	688	1946	24956	5176	0	39447	11641	3487	2988	.	.	.	.	.	.
4.3	0	4229	10919	87	0	5475	341	0	10148	0	4711	3656	.	.	.	.	.	.
4.2	0	716	2943	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.
Total 4	0	4945	20977	755	1946	30431	5517	0	49595	11641	8198	6644	.	.	.	.	.	.
5.5	0	0	0	0	0	0	14201	793	9939	0	0	4582	.	.	.	.	.	.
5.4	0	16	1775	1499	77	1765	35141	45520	416	1073	872	4674	.	.	.	.	.	.
5.3	0	3012	3619	237	0	0	597	1099	0	2310	0	0	.	.	.	.	.	.
5.2	0	666	72	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.
Total 5	0	3694	5466	1736	77	1765	49939	47412	10355	3383	872	9256	.	.	.	.	.	.
6.5	0	0	0	0	0	0	654	1673	416	0	0	0	.	.	.	.	.	.
6.4	6290	28	7165	699	1814	0	1244	3786	5678	0	0	0	.	.	.	.	.	.
6.3	6290	1501	0	614	52	0	0	0	0	0	0	0	.	.	.	.	.	.
Total 6	12580	1529	7165	1313	1866	0	1898	5459	6094	0	0	0	.	.	.	.	.	.
7.5	0	0	0	0	0	0	28	0	1050	0	0	0	.	.	.	.	.	.
7.4	0	0	0	248	103	0	114	535	1605	0	0	0	.	.	.	.	.	.
7.3	0	0	0	105	597	0	0	0	0	0	0	0	.	.	.	.	.	.
Total 7	0	0	0	353	700	0	142	535	2655	0	0	0	.	.	.	.	.	.
8.4	0	0	0	0	597	0	0	0	0	0	0	0	.	.	.	.	.	.
8.3	0	0	1353	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.
Total 8	0	0	1353	0	597	0	0	0	0	0	0	0	.	.	.	.	.	.
9.4	164	446	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.
10.4	164	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.
New Recruit	.	.	.	.	.	.	.	.	.	.	.	.	34696	15562	1229	24934	12930	13514
Previous Spawner	.	.	.	.	.	.	.	.	.	.	.	.	44557	1798	1532	7812	21002	29213
Total	12908	11800	36518	4326	5861	34348	57496	66670	117988	108586	48787	16090	79253	17360	2761	32746	33932	42727
% new recruit	1	6	20	19	45	79	34	21	84	97	89	48	44	90	45	76	38	32
Major YC	1979	1981	1981	1983	1984	1984	1985	1987	1987	1989	1990	1990	.	.	.	.	.	.
% of Total	97	42	57	40	33	89	87	71	42	86	81	58	.	.	.	.	.	.

M121

IMPORTANT NOTE CONCERNING THE FOLLOWING PAGES

THE PAGES WHICH FOLLOW HAVE BEEN FILMED TWICE IN ORDER TO OBTAIN THE BEST REPRODUCTIVE QUALITY

USERS SHOULD CONSULT ALL THE PAGES REPRODUCED ON THE FICHE IN ORDER TO OBTAIN A COMPLETE READING OF THE TEXT.

REMARQUE IMPORTANTE CONCERNANT LES PAGES QUI SUIVENT

LES PAGES SUIVANTES ONT ÉTÉ REPRODUITES EN DOUBLE AFIN D'AMÉLIORER LA QUALITÉ DE REPRODUCTION

LES UTILISATEURS DOIVENT CONSULTER TOUTES LES PAGES REPRODUITES SUR LA FICHE AFIN D'OBTENIR LA LECTURE DU TEXTE INTÉGRAL

Micromedia
ProQuest

20 Victoria Street
Toronto, Ontario M5C 2N8
Tel.: (416) 362-5211
Toll Free: 1-800-387-2689
Fax: (416) 362-6161
Email: info@micromedia.on.ca

Table 8. Estimated returns (thousands) based on the catch-at-age matrix, 1983 to 2000 assuming M = 0.4. F of oldest age group in the cohort and for the present year's fishery (2000) are tuned using the larval survey as an index of escapement. Numbers in bold (and grey shading) are values for which oldest age F for the year is applied. Tuning was performed using Excel Solver and maximizing the correlation of ln(escapement) and ln(larval index). The oldest age Fs were constrained at >= 0.1. Starting Fs for the tuning were generally set at 1.0 for all years but alternate greater and lesser values were run to ensure the detection of the global minimum.

M =	**0.40**																	
Oldest age F	5.0	0.1	21.1	15.9	25.9	12.5	1.1	12.3	0.1	2.6	7.2	12.3	11.6	0.1	0.1	0.1	0.1	0.3
Correlation	**0.85**	**<<-- to maximize**																
Age	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
2 2		160	71	**2**			**1**		24	**5**	3			**10**				**4**
3 2	**2**		**107**	31						12		**2**						
4 2					**10**						**6**							
3 3	1209	4277	750	2293	8540	5416	330	3106	680	2182	3091	135	707	148	2478	1743	237	**522**
4 3	733	333	1124	203	691	2775	1969	141	201	173	273	423	78	243	50	931	790	**111**
5 3	347	225	50	136	29	176	281	491	58	107	27	**82**	123	**32**	**105**	22	286	**355**
6 3	66	8	**27**	**6**	**5**	**7**	10	67	**166**	**2**	**7**	**4**		23			**11**	**103**
7 3	32	**9**	**3**					**3**	**8**						**11**			
8 3	**3**	**9**																
9 3	**5**																	
4 4	450	758	4028	430	870	1787	3731	367	1369	263	705	1824	158	265	49	428	949	**206**
5 4	431	53	221	642	**131**	292	239	863	58	57	50	94	252	29	29	19	136	**378**
6 4	53	**183**	12	**11**	**181**		17	35	**157**	**1**	**7**	**7**	21	29	**11**	**11**	**11**	**61**
7 4	55	5	0	**4**				**4**	**8**					**11**	**11**			
8 4	591	**37**	**1**															
9 4		**394**																
5 5	14	1	10				21	**36**	**290**		9	45	**8**	**63**	**11**		**11**	**11**
6 5	**5**	**9**	**1**	**7**				13				**1**	19					
7 5									**8**					**11**				
6 6														**14**				
Ln(escapement)	7.54	7.96	7.35	7.35	8.49	8.23	7.79	6.90	6.99	6.32	6.82	6.60	6.33	6.10	7.38	7.52	7.33	7.16
Escapement	1890	2878	1552	1563	4848	3754	2414	992	1088	554	915	734	560	448	1598	1849	1531	1292
Total run	3995	6463	6405	3766	10457	10453	6600	5127	3028	2804	4180	2617	1365	895	2753	3153	2430	1751
Catch	2105	3585	4853	2203	5609	6699	4186	4135	1940	2250	3265	1883	805	447	1155	1304	899	459
Annual F	0.75	0.81	1.42	0.88	0.77	1.02	1.01	1.64	1.02	1.62	1.52	1.27	0.89	0.69	0.54	0.53	0.46	0.30
Larval indices																		
Historical	528	1534	275				797	240	557		182	201	120	285	600	1284	694	297
Larvaldays	30833	102124	18281				42131	13940	22684		10614	11077	4015	13233	25463	79655	31983	14797
Ln(larvaldays)	10.34	11.53	9.81				10.65	9.54	10.03		9.27	9.31	8.30	9.49	10.14	11.29	10.37	9.60

Table 8. Estimated returns (thousands) based on the catch-at-age matrix, 1983 to 2000 assuming M = 0.4. F of oldest age group in the cohort and for the present year's fishery (2000) are tuned using the larval survey as an index of escapement. Numbers in bold (and grey shading) are values for which oldest age F for the year is applied. Tuning was performed using Excel Solver and maximizing the correlation of ln(escapement) and ln(larval index). The oldest age Fs were constrained at >= 0.1. Starting Fs for the tuning were generally set at 1.0 for all years but alternate greater and lesser values were run to ensure the detection of the global minimum.

M =	0.40																	
Oldest age F	5.0	0.1	21.1	15.9	25.9	12.5	1.1	12.3	0.1	2.6	7.2	12.3	11.6	0.1	0.1	0.1	0.1	0.3
Correlation	0.85	<-- to maximize																
Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
2.2		160	71	**2**			**1**		24	**5**	3			**10**				**4**
3.2	**2**		**107**	31						12		**2**						
4.2					**16**						**6**							
3.3	1209	4277	750	2293	8540	5416	330	3106	680	2182	3091	135	707	148	2478	1743	237	**522**
4.3	733	333	1124	203	691	2775	1969	141	201	173	273	423	78	243	50	931	790	**111**
5.3	347	225	50	136	29	176	281	491	58	107	27	**82**	123	**32**	**105**	22	286	**393**
6.3	66	8	**27**	**6**	**5**	**7**	10	67	**186**	**2**	**7**	**4**		23			**11**	**123**
7.3	32	**9**	**3**					**3**	**6**						**11**			
8.3	**3**	**9**																
9.3	**5**																	
4.4	450	758	4028	430	870	1787	3731	367	1369	263	705	1824	158	285	49	428	949	**268**
5.4	431	53	221	642	**131**	292	239	863	58	57	50	94	252	29	29	19	136	**378**
6.4	53	**183**	12	**11**	**181**		17	35	**157**	**1**	**7**	**7**	21	29	**11**	**11**	**11**	**41**
7.4	55	5	0	**4**				**4**	**6**					**11**	**11**			
8.4	591	**37**	**1**															
9.4		**394**																
5.5	14	1	10				21	**35**	**250**		9	45	**8**	**63**	**11**		**11**	**11**
6.5	**5**	**9**	**1**	**7**				13				**1**	19					
7.5									**6**					**11**				
6.6														**14**				
Ln(escapement)	7.54	7.96	7.35	7.35	8.49	8.23	7.79	6.90	6.99	6.32	6.82	6.60	6.33	6.10	7.38	7.52	7.33	7.16
Escapement	1890	2878	1552	1563	4848	3754	2414	992	1088	554	915	734	560	448	1598	1849	1531	1292
Total run	3995	6463	6405	3766	10457	10453	6600	5127	3028	2804	4180	2617	1365	895	2753	3153	2430	1751
Catch	2105	3585	4853	2203	5609	6699	4186	4135	1940	2250	3265	1883	805	447	1155	1304	899	459
Annual F	0.75	0.81	1.42	0.88	0.77	1.02	1.01	1.64	1.02	1.62	1.52	1.27	0.89	0.69	0.54	0.53	0.46	0.30
Larval Indices																		
Historical	528	1534	275				797	240	557		182	201	120	285	600	1284	694	297
Larvaldays	30833	102124	18281				42131	13940	22684		10614	11077	4015	13233	25463	79655	31983	14797
Ln(larvaldays)	10.34	11.53	9.81				10.65	9.54	10.03		9.27	9.31	8.30	9.49	10.14	11.29	10.37	9.60

Table 9. Exploitation histories of the 1979 to 1997 year-classes in the Margaree River gaspereau fishery. Percent new recruitment (% New Recruitment) is based on summation of the catch-at-age matrix. Percent of year-class harvested is based on the estimated abundance of the year class from cohort analysis.

YEAR CLASS		3 Year Olds	4 Year Olds	5 Year Olds	6 Year Olds	7 Year Olds		% New Recruitment	% of Year Class Harvested	
									Overall	As new recruits
	Year	1982	1983	1984	1985	1986	Total			
1979	Catch (1000's)	?	788	221	34	4	1027	> 36		
	New recruitment	?	371	0	0	0	371			
	Year	1983	1984	1985	1986	1987	Total			
1980	Catch (1000's)	715	687	245	23	0	1670	68%	85%	58%
	New recruitment	713	428	0	0	0	1141			
	Year	1984	1985	1986	1987	1988	Total			
1981	Catch (1000's)	2601	3990	501	186	0	7278	78%	88%	68%
	New recruitment	2601	3070	0	0	0	5671			
	Year	1985	1986	1987	1988	1989	Total			
1982	Catch (1000's)	554	394	149	7	0	1104	62%	82%	51%
	New recruitment	447	235	0	0	0	682			
	Year	1986	1987	1988	1989	1990	Total			
1983	Catch (1000's)	1278	873	428	17	7	2596	65%	81%	53%
	New recruitment	1262	434	0	0	0	1696			
	Year	1987	1988	1989	1990	1991	Total			
1984	Catch (1000's)	4400	3786	368	79	3	8633	68%	83%	56%
	New recruitment	4400	1431	1	1	1	5833			
	Year	1988	1989	1990	1991	1992	Total			
1985	Catch (1000's)	2479	3680	908	39	0	7106	70%	77%	54%
	New recruitment	2479	2444	36	0	0	4959			
	Year	1989	1990	1991	1992	1993	Total			
1986	Catch (1000's)	120	335	148	3	0	604	72%	61%	44%
	New recruitment	120	281	35	0	0	436			
	Year	1990	1991	1992	1993	1994	Total			
1987	Catch (1000's)	2806	1324	144	14	0	4288	95%	96%	91%
	New recruitment	2806	1283	0	0	0	4089			
	Year	1991	1992	1993	1994	1995	Total			
1988	Catch (1000's)	422	321	89	11	0	823	75%	86%	65%
	New recruitment	422	188	8	1	0	619			
	Year	1992	1993	1994	1995	1996	Total			
1989	Catch (1000's)	1776	722	162	8	1	2669	88%	91%	80%
	New recruitment	1774	564	17	0	0	2355			
	Year	1993	1994	1995	1996	1997	Total			
1990	Catch (1000's)	2460	1698	306	21	2	4475	88%	91%	79%
	New recruitment	2460	1448	8	1	0	3917			
	Year	1994	1995	1996	1997	1998	Total			
1991	Catch (1000's)	21	146	22	1	0	190	74%	53%	39%
	New recruitment	19	115	6	0	0	140			
	Year	1995	1996	1997	1998	1999	Total			
1992	Catch (1000's)	345	328	24	1	0	698	84%	70%	59%
	New recruitment	345	242	1	0	0	588			
	Year	1996	1997	1998	1999	2000	Total			
1993	Catch (1000's)	73	39	9	2	0	123	76%	82%	48%
	New recruitment	73	21	0	0	0	94			
	Year	1997	1998	1999	2000		Total			
1994	Catch (1000's)	1089	730	178	43		2040	64%	70%	45%
	New recruitment	1089	225	1	0		1315			
	Year	1998	1999	2000			Total			
1995	Catch (1000's)	564	847	195			1406	68%	52%	35%
	New recruitment	564	386	3			953			
	Year	1999	2000				Total			
1996	Catch (1000's)	72	83				155	81%		
	New recruitment	72	54				126			
	Year	2000					Total			
1997	Catch (1000's)	137					137	100%		
	New recruitment	137					137			

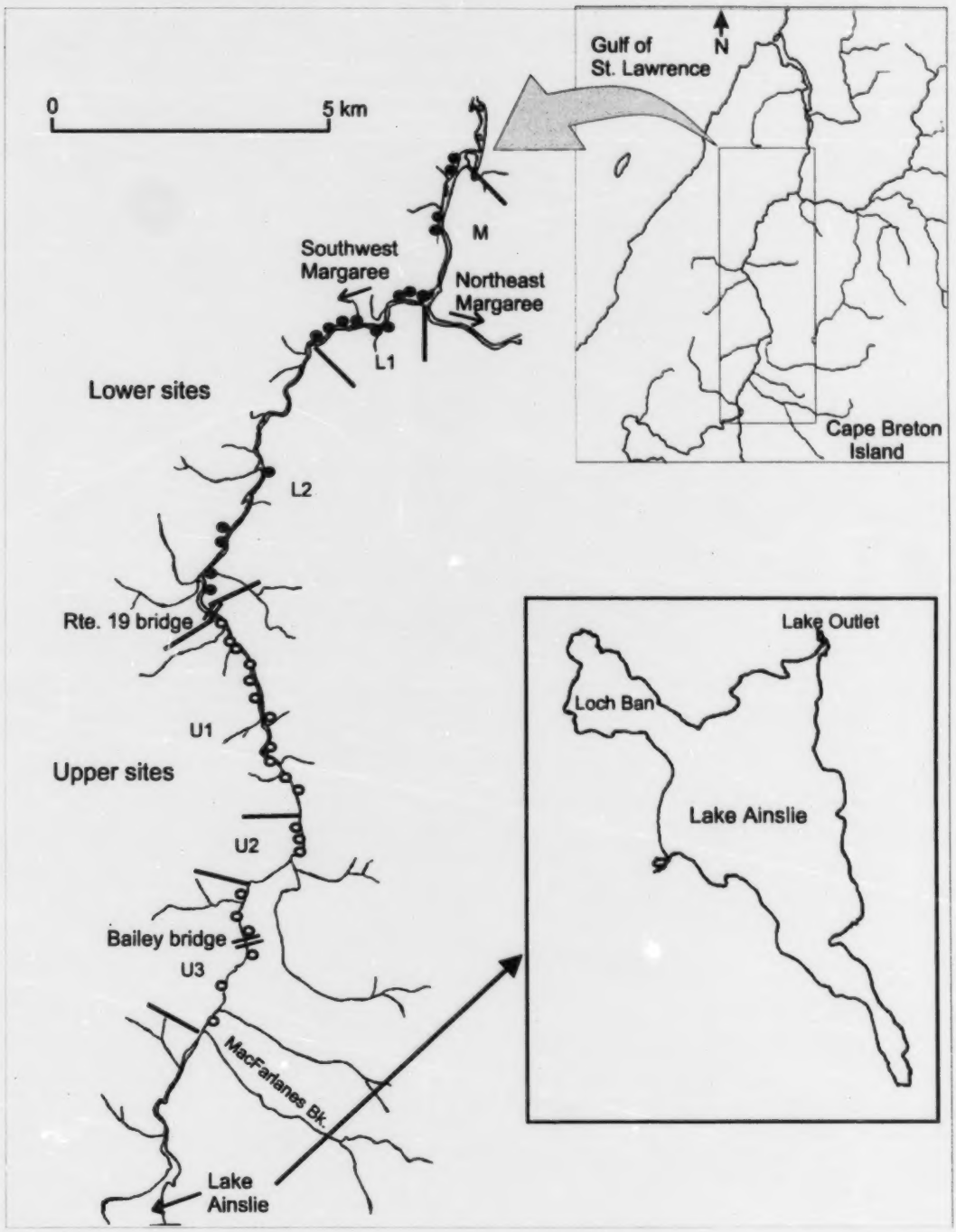


Figure 1. Gaspereau trap sites of the Margaree River and Lake Ainslie.

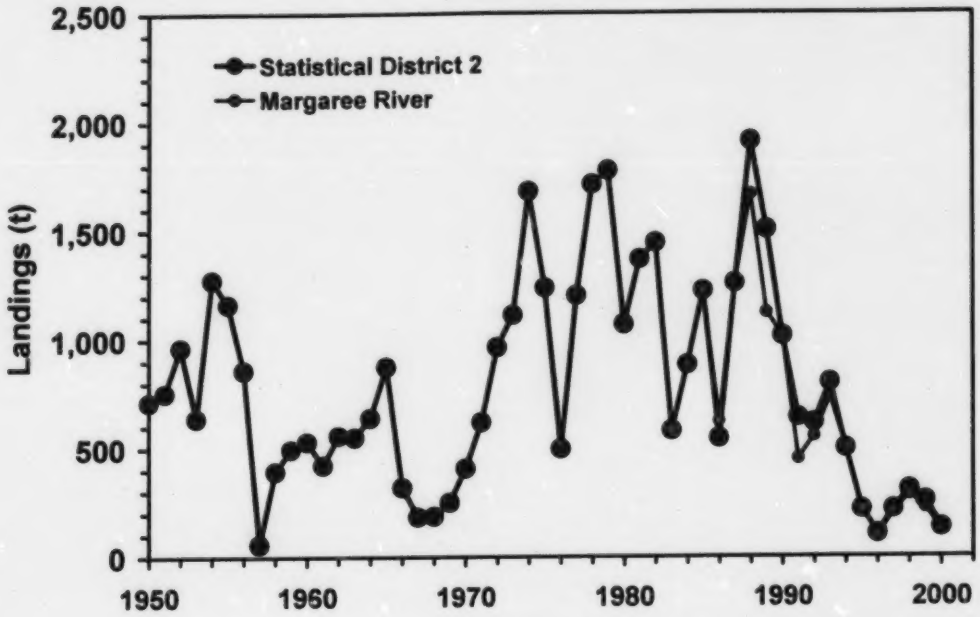
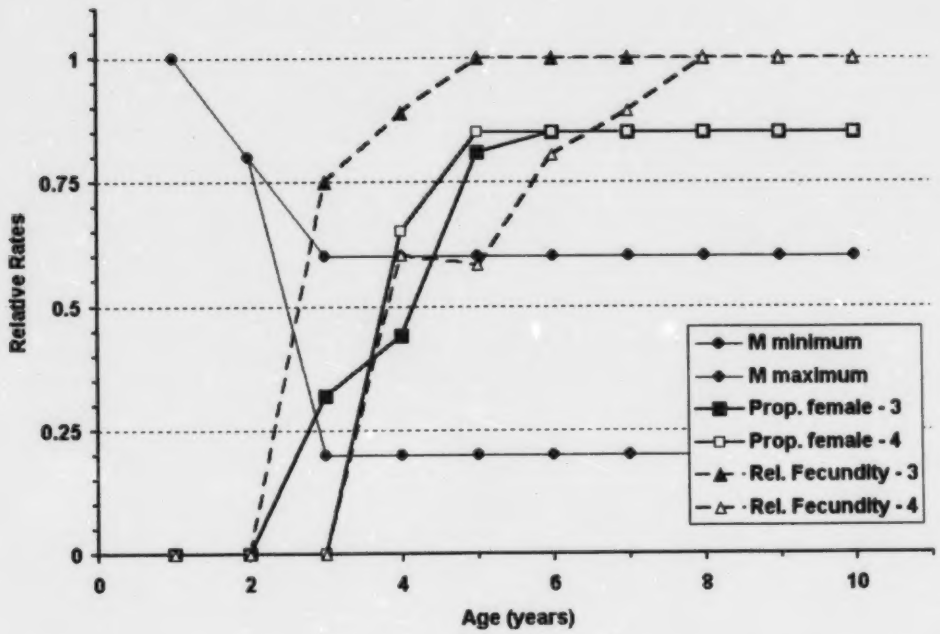


Figure 2. Landings (t) of gaspereau from Statistical District 2 (1950 to 2000) and the Margaree River (1983 to 2000) fisheries.



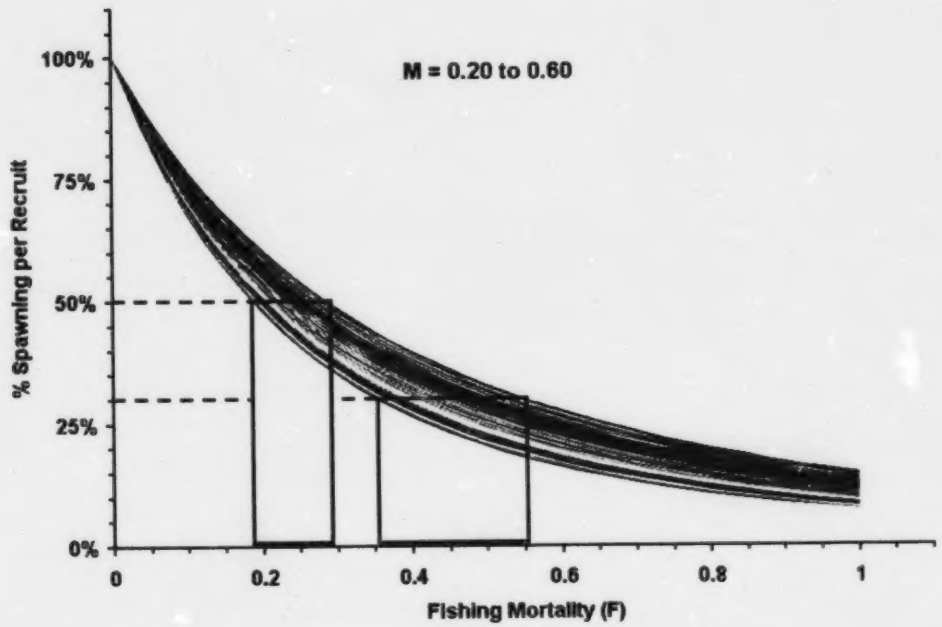


Figure 3. Life history input variables (upper) and % Spawning per Recruit (%SPR) (lower) for the alewife stock of the Margaree River for assumptions of M between 0.2 and 0.6. The width of the rectangle defines the lower and upper bounds of F resulting from uncertainty in M.

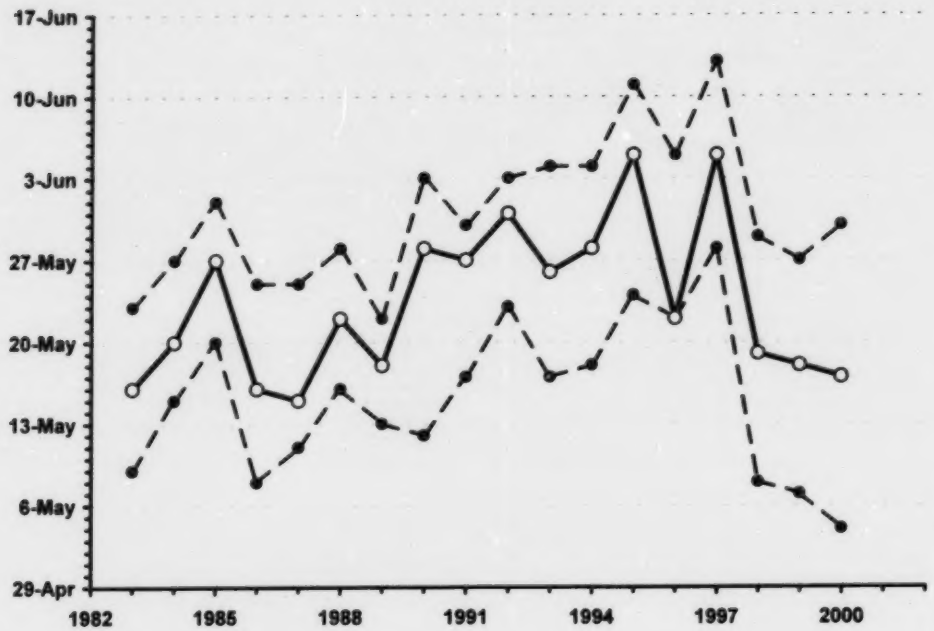


Figure 4. Timing of the fishery as shown by the median and 10% to 90% dates of the catch as reported in the logbooks from the fishery.

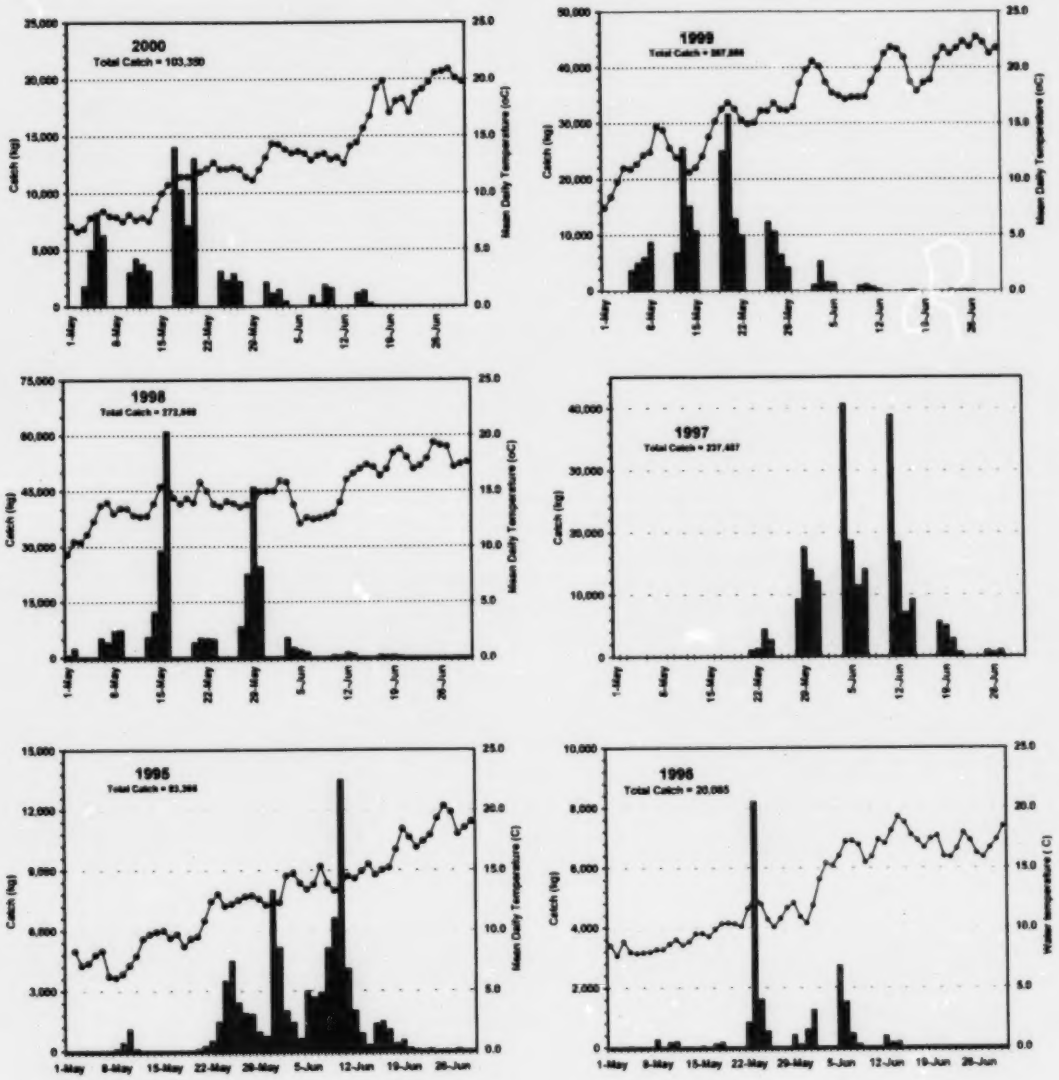


Figure 5. Margaree River reported logbook catches (kg) relative to date and water temperature for 1995 to 2000. Temperature data are not available for 1997 because the temperature recorder was lost.

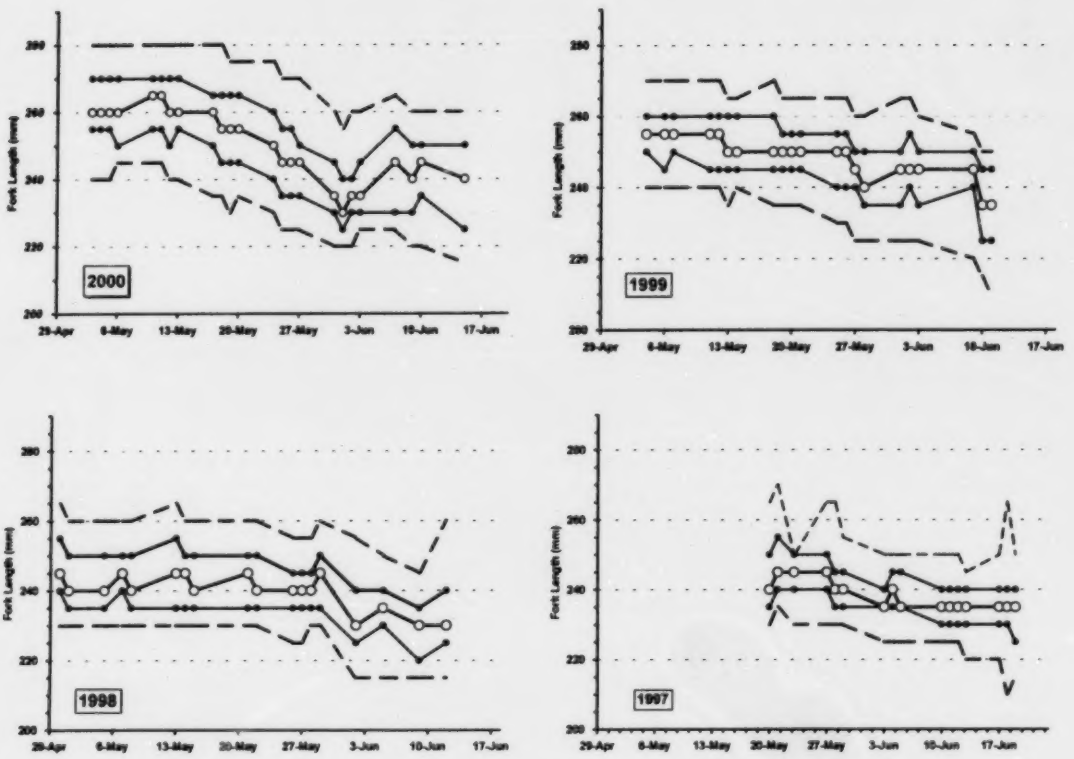


Figure 6. Length distributions of gaspereau (majority alewife) in the catches relative to the date of the fishery, 1997 to 2000. Lines define the median length (open circles), 25th to 75th percentile range (black dots) and the 5th to 95th percentile range (dashed lines) from the samples.

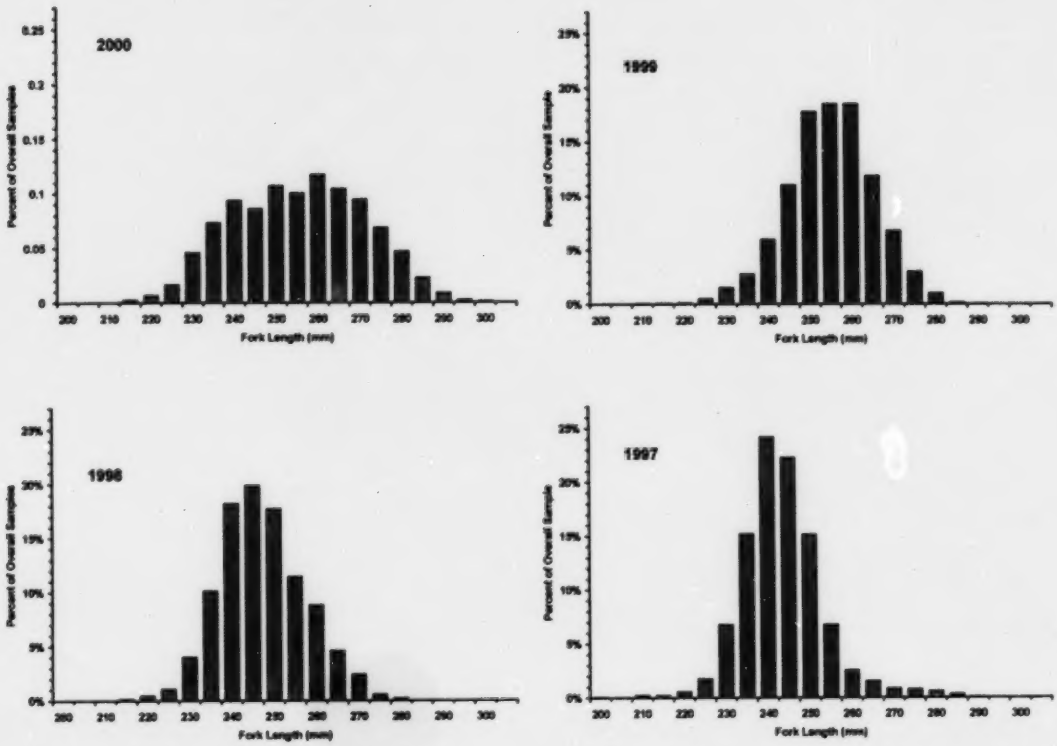


Figure 7. Overall length frequency distribution of alewife (weighted by the catches) in the catches from the Margaree River, 1997 to 2000.

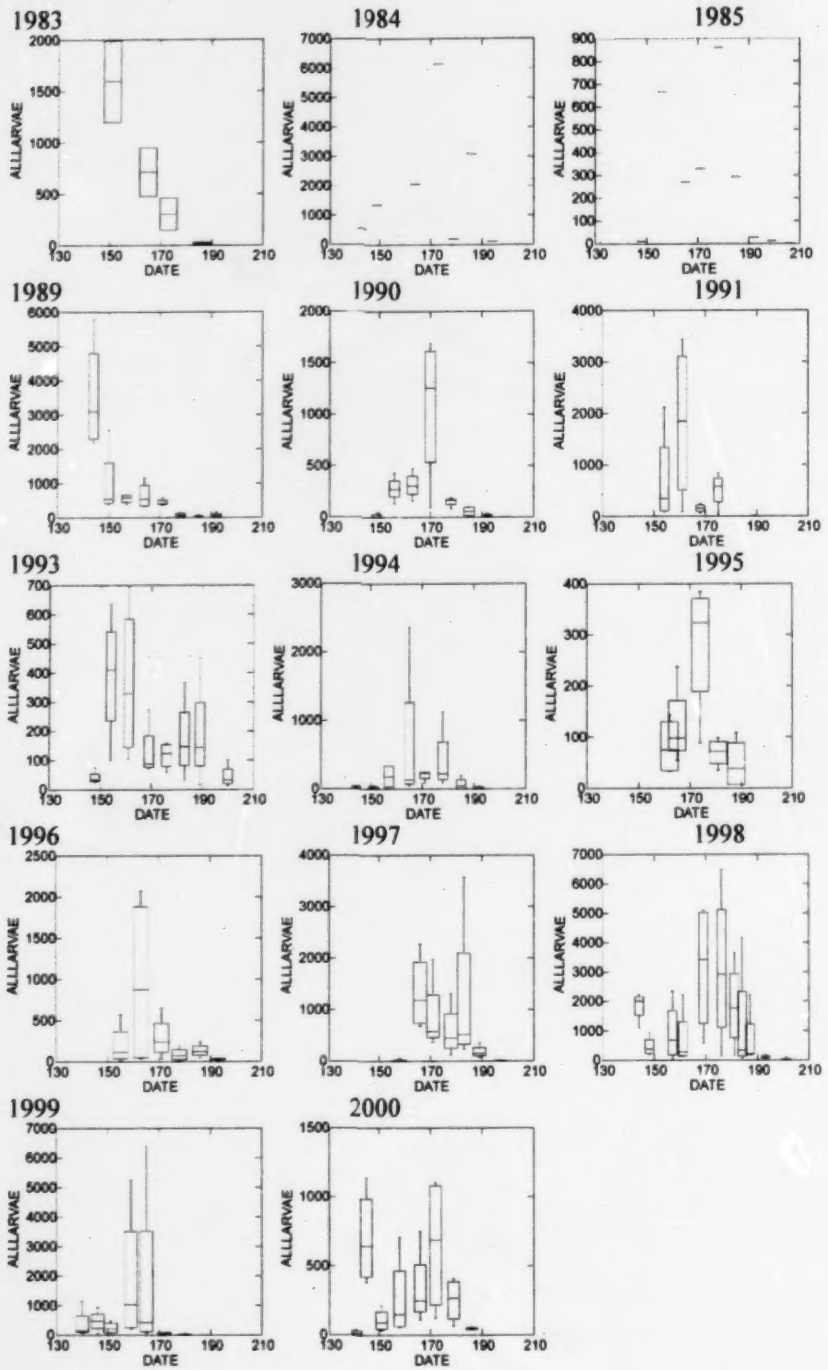


Figure 8. Densities of all larvae (prolarvae and postlarvae) by date at the sites sampled within Loch Ban, 1983 to 2000. In 1983 to 1985, only one site (site 3) in Loch Ban was sampled but two sizes of plankton nets were used at each site in 1983. Box plots represent median (horizontal line within the box) interquartile range (box), 1.5 times the interquartile range (vertical line). Date 150 = May 30. Single dashes for 1984 and 1985 indicate that only one sample per period was collected.

Larval index	Total Larvae				Prolarvae	
		Previous	Relative index			
Year	Larvaldays	Index	Larvaldays	Previous	Larvaldays	Relative
1983	30833	528	1.17	0.99		
1984	102124	1534	3.89	2.89		
1985	18281	275	0.70	0.52		
1989	42131	797	1.60	1.50	16914	1.48
1990	13940	240	0.53	0.45	2235	0.20
1991	22684	557	0.86	1.05	13806	1.21
1993	10614	182	0.40	0.34	5219	0.46
1994	11077	201	0.42	0.38	4213	0.37
1995	4015	120	0.15	0.23	2362	0.21
1996	13233	285	0.50	0.54	3222	0.28
1997	25463	600	0.97	1.13	6880	0.60
1998	79655	1284	3.03	2.42	35749	3.14
1999	31983	694	1.22	1.31	25765	2.26
2000	14797	297	0.56	0.56	9010	0.79

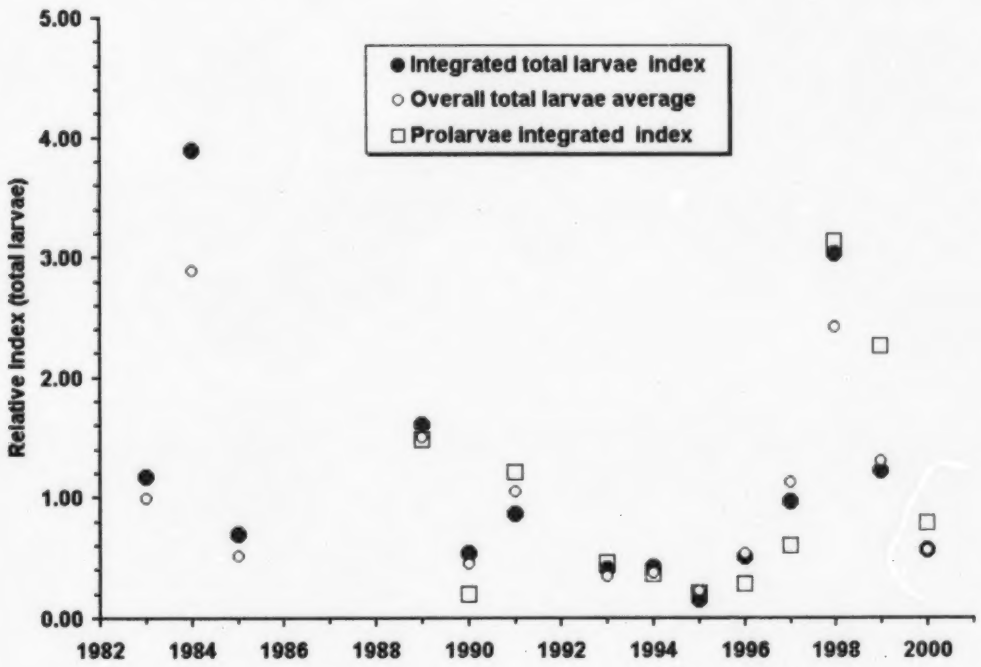


Figure 9. Relative index (index relative to 1983 to 1996 average) based on historical overall average abundance (larvae per 100 m^3) and the integrated abundance (larval days) for the entire sampling period. The integrated index for prolarvae only is shown for 1989 to 2000.

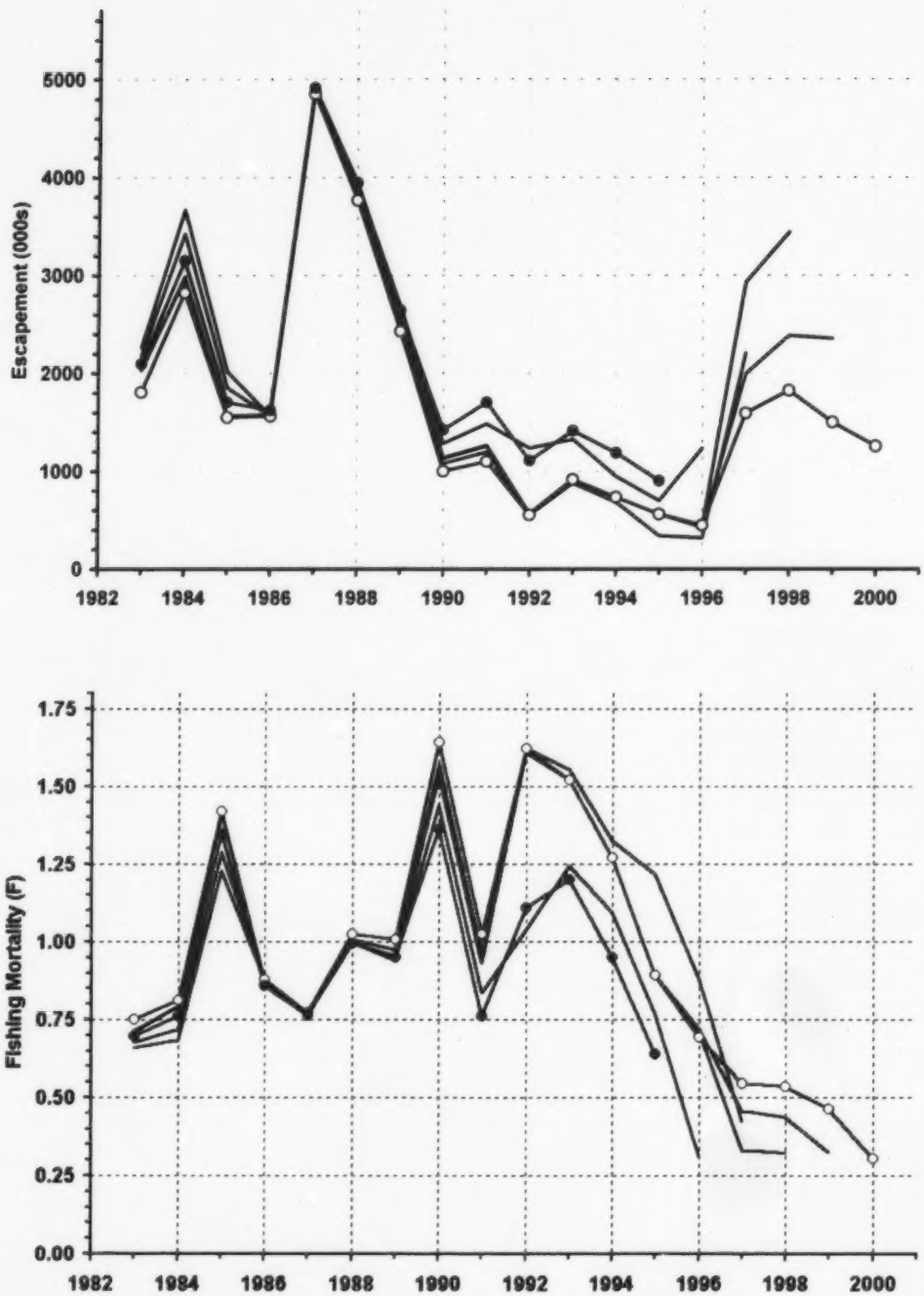


Figure 10. Retrospective pattern in escapement (number of fish by thousand; upper) and fishing mortality (F; lower) when tuning with the integrated larval index for the season and with M = 0.4. The line with the solid bullet is the estimate for the catch matrix up to and including year 1995 and the line with the open circle is the estimate up to and including year 2000. Other lines are for 1996 to 1999 sequences of data.

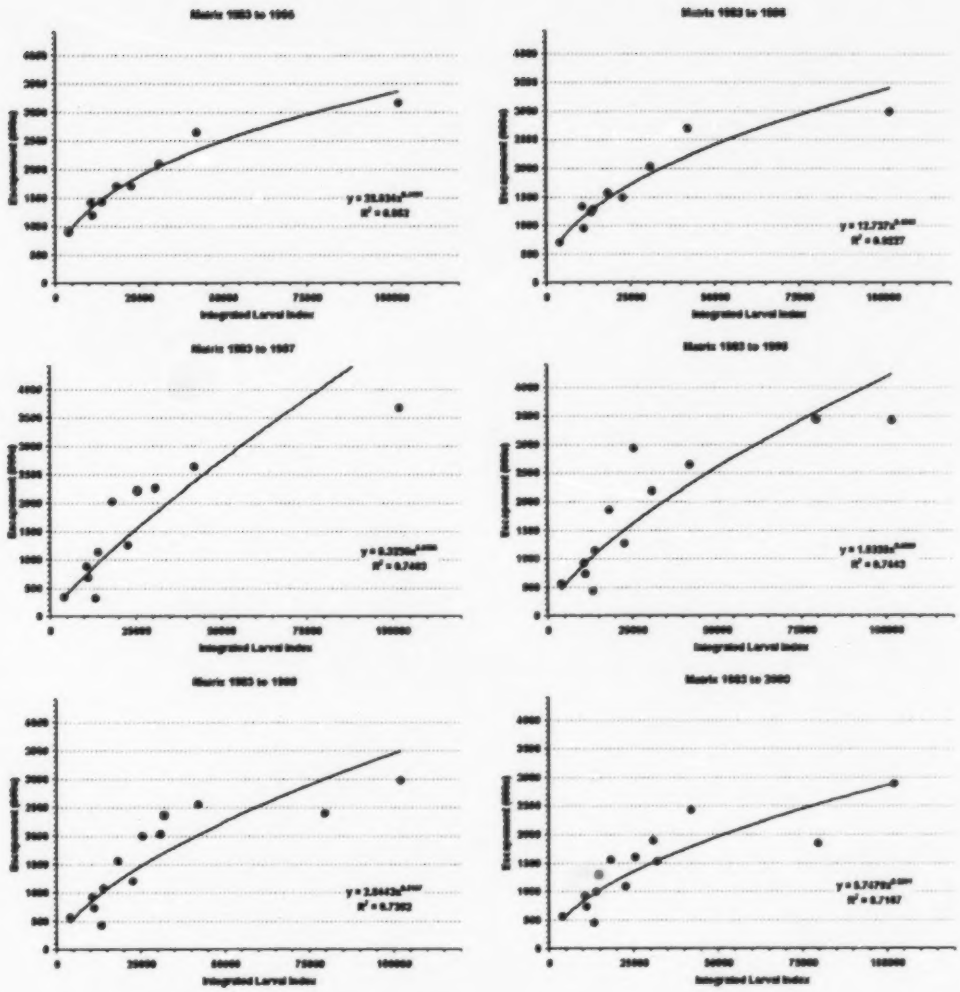


Figure 11. Relationships between larval index and estimated escapement into Lake Ainslie. The grey bullet is the value for the current year.

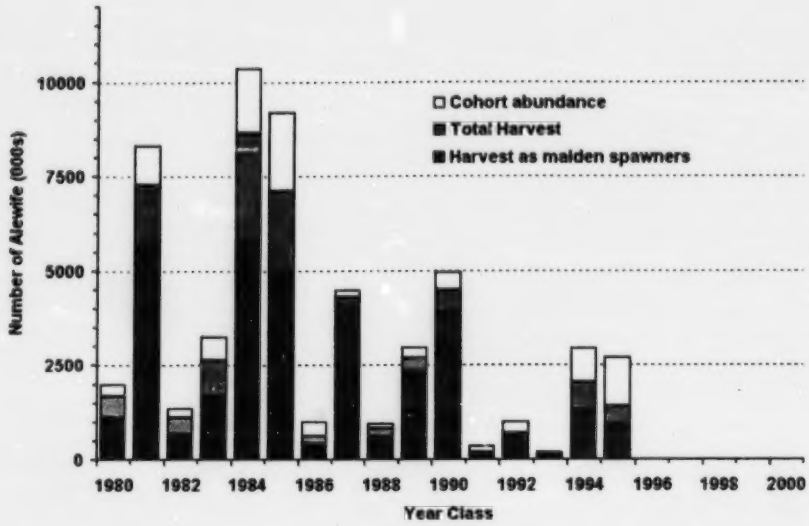


Figure 12. Estimated total year class abundance (top of white bar), total harvest of the year class (top of grey bar), and harvest of year class taken as first time spawners (top of black bar), for alewife from the Margaree River. Weak year classess (< 1 million fish) occurred in 1986, 1988, 1991 to 1993.

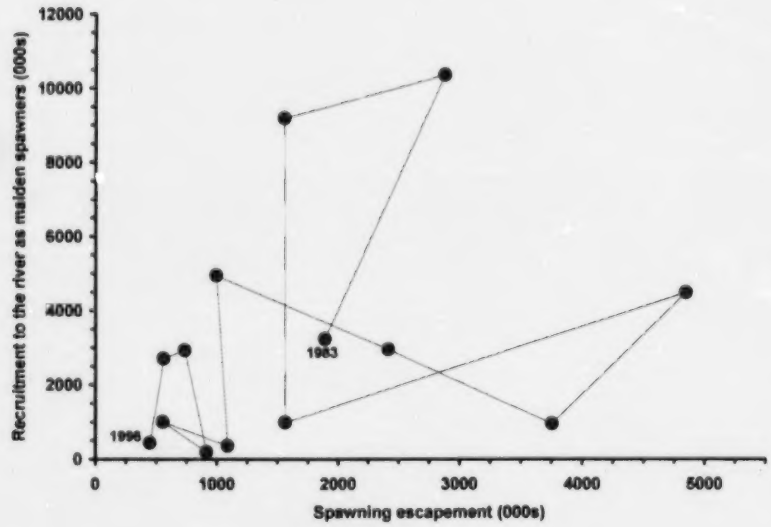


Figure 13. Stock and recruitment plot for alewife from the Margaree River. Year label is the year of spawning (cohort year).